Western Forest Products Limited

Tree Farm Licence 6

Quatsino Sound – North Vancouver Island

Timber Emphasis

VRI Ground Sampling Plan

Submitted to:

Vancouver Forest Region
Ministry of Forests
Nanaimo, BC

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Executive Summary

This document provides detailed plans and rationale for the Vegetation Resources Inventory Phase II (Inventory) and Net Volume Adjustment Factor (NVAF) Sampling of Tree Farm Licence 6.

The target population is the Vegetated Treed (VT) portion of TFL 6, excluding private lands, Parks and other legally recognized Protected Areas. Sample polygons were selected from the target population of 26,145 polygons using a stratified probability proportional to size with replacement (PPSWR) sampling technique. Two strata were created based on grouping leading species and total polygon volume from VRI Phase I Forest Cover Maps. The population was further stratified into sub-strata based on age class and productivity grouping. Up to 100 VRI sample clusters will be established.

Net volume adjustment factor sampling will enhance up to 20 of the VRI sample clusters. To select NVAF sample plots VRI sample polygons were stratified by age class and leading species, based on VRI Phase I Forest Cover Polygons. All sampling will be completed in 2001. The estimated total cost of the VRI and NVAF are $375,000 collectively. These costs include installation of the VRI sample clusters and statistical analysis.

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Introduction

Quatsino Tree Farm Licence 6 is located on northern Vancouver Island throughout the vicinity of Quatsino Sound. The total area of the TFL is approximately 198,113 hectares (ha) of which 156,769 ha are Crown Land and 41,334 ha are fee simple lands in the form of Timber Licences. The Crown Lands are comprised of two disjoined areas; Block 1 is the largest management unit and includes watersheds that drain westward into Quatsino Sound and San Josef Bay. Block 2 includes watersheds that drain northeastward into Queen Charlotte Strait between Fort Rupert and Port McNeill, as well as Waukwaas watershed and Rupert Arm. Municipalities, road right-of-ways, private land and parkland exist throughout both blocks. Administratively, the TFL is situated within the Port McNeill Forest District of the Vancouver Forest Region.

The existing inventory of TFL 6 was started in 1968 based on aerial photographs taken in 1967. The inventory was completed to standard in 1970. Although this inventory has been regularly updated for denudations and regeneration, a new inventory is needed to reflect current forest conditions.

Funding for this VRI/NVAF project comes from Western Forest Products' (WFP) multi-year agreement with Forest Renewal BC. The project was initiated in 1999; it is expected to be complete in 2001.

This VRI Phase II Ground Sampling Plan provides the Vancouver Region of the Ministry of Forests (MOF, the Ministry) and the contractor, Olympic Resources Management (ORM, the Contractor) with a detailed outline of sampling activities and objectives to be completed over the next year.

TFL 6 Landbase

The TFL is 198,113 ha of which 173,788 hectares are Vegetated Treed (VT) (BC Landcover Classification Scheme). The target population is the VT portion of the TFL, excluding private lands, parks and other officially protected areas. The TFL 6 Phase I photo interpretation of forest cover will provide the basis of units to be sampled. The main tree species in the TFL are Hw (66%) and Cw (22%) reported by area as a leading species (Table 1).

Table 1. TFL 6 landbase.

Age Class	Hectares										Total	%
	Hw	Cw	Yc	Dr	Ss	Ba	Hm	Fd	Pl	Ac		
0-20	11605	3705	40	363	445	132		191	38		16519	10%
21-40	25717	3938	163	2470	1722	291	7	639	54	1	35002	20%
41-60	12347	820	3	1688	27	10	4	35	7		14940	9%
61-80	11426	46		280	38	77	3	181		13	12065	7%
81-100	5232	26		29	2	175	8	86		2	5561	3%
101-120	5492	22	12	25	101	148		20			5820	3%
121-140	1249	38	17	6	8	266	5	82			1671	1%
141-160	980	1286	328	1	13	72	76		13		2768	2%
161-200	18292	15616	4993		339	786	702	120	43		40891	24%
201-250	20421	6382	1164		305	357	748	68			29444	17%
250+	1991	6234	461		135	32	232	3	18		9106	5%
Total	114753	38113	7180	4862	3135	2347	1785	1424	172	16	173787	
%	66%	22%	4%	3%	2%	1%	1%	1%	0%	0%		

Area of Interest

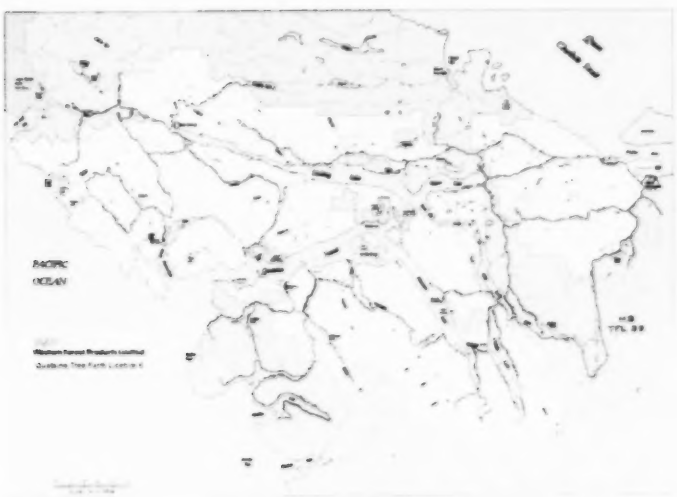

Figure 1. TFL 6

VRI Phase II - Sampling Plan

Objectives

The main objective of this timber emphasis inventory is to:

> *Install a number of VRI sample clusters sufficient to adjust the timber inventory in the TFL Vegetated Treed (VT) areas with a sampling error of ±10% (95% probability) for overall net timber volume in the VT areas.*

Net timber volume is gross volume minus stumps, tops, decay, waste, and breakage. Decay and waste are normally estimated using VRI call grading/net factoring and NVAF sampling.

Sample Size

To meet the inventory objectives (section 2.3), a minimum sample size of 100 VRI sample clusters is recommended, with approximately 71 samples in the Hemlock strata and 29 in the Cedar Strata (Figure 1, Table 2).

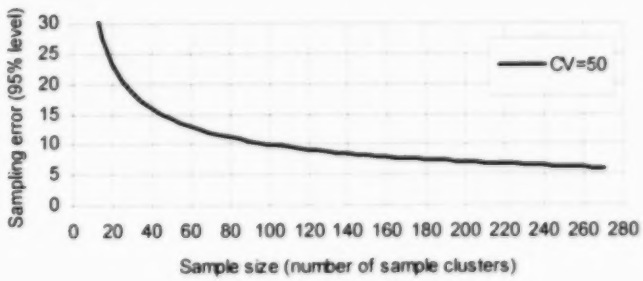

Figure 2. Decreasing sampling error with increasing sample size[1]

Table 2. Sample cluster distribution in the VT landbase.

Landbase	Area (%)	Number of clusters
Hemlock Strata (Hw, Ss, Ba, Hm, Fd)	71%	71
Cedar Strata (Cw, Yc, Dr, Pl, Ac)	29%	29
Total	100	100

[1] This figure is used as an example only: coefficient of variation (CV) estimated from cruise plots in the TFL indicates a CV of 42%.

Sample Selection

Sample polygons were selected according to the stratified probability proportional to size with replacement (PPSWR) sample selection method and the recently completed Phase I inventory. Appendix A fully outlines the steps in stratifying and selecting samples. Stratification was based on species groups, age groups and polygon productivity/volume groups. Samples for the entire VT landbase is summarized in Appendix B. Sample allocation to individual strata and substrata was proportional to strata or sub-strata areas. PPSWR was applied to each sub-stratum. Comparison of the VT population and the sample proportions is provided in Appendix C.

Given the exploded plot cluster design with 50m between the main plot and the auxiliary plots, and the detail of the forest cover typing in the TFL (large number of small polygons and/or irregular elongated polygons), the number of auxiliary plots falling outside the selected polygon is demonstrated to be in the order of 30% from past projects. In order to reduce this loss, **it has been proposed that the distance between the plot centre and auxiliary plot be reduced from 50m to 30m**. This will allow maintenance of the provincial grid. Reducing cluster plots distances will lessen the number of plots dropped, improving logistic and sampling efficiency.

Net Volume Adjustment Factor Sampling (NVAF)

The VRI samples enhanced for NVAF measurements are identified in Appendix B. NVAF measurements will include detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume (where estimated net volume is obtained from net factoring and taper equations). Sixty trees (50 live, 10 dead) selected from 20 VT polygons (selected with at random from the Phase II sample clusters) will be selected in the VT target population and destructively sampled for NVAF. Of the 20 VT polygons, 12 have been selected from mature stands while 8 are from immature stands.

Measurements

The ground samples will be VRI Timber Emphasis (TE) sample clusters. Measurements will be based on the VRI Ground Sampling manual Version 4.1. The decision to do only TE sample clusters has been made, as detailed ecological classification was considered redundant since the entire TFL has been ecologically mapped in detail (to the site series).

The attributes to be sampled will be only those that can be used to adjust the Phase I classification variables. These are:

- Header Information – Card #1, Compass Card #2 & Cluster Layout Card #3 will be completed.
- Tree Details – Card #8 (Main Plot) Data Collected: species, diameter, length, crown class, height to green crown, grade, log length, sound wood percentage (net factor) and wildlife codes.
- Auxiliary Plot – Card # 11 (Auxiliary Plots – 4) Data Collected: species, DBH and all data as recorded on tree detail card for any species not recorded in the main plot. A separate card is completed for each of the four auxiliary plots.
- Tree Loss Indicators – Card # 9 Data Collected: Damage agents, loss indicators and stem mapping bearings and distances. The loss indicators are used in the Net Volume Adjustment sampling.
- Site Tree Data and Small Tree, Stump – Card # 10 Data Collected: Top height and random tree data – heights, ages, etc. This card also records small trees (less than 4cm at DBH) and stumps shorter than 1.3 metres in length.
- Coarse Woody Debris – Cards # 6 & 7 (Card #6 for transect 1 and Card # 7 for transect 2) Data Collected: species, diameter and transect measurements. ***Note:*** *Coarse Woody Debris data will only be collected where the plot is free from excessive snow and time permits. Plots where data cannot be collected* ***will not*** *be revisited.*

Cruiser Qualification and Quality Assurance

All cruisers are certified in timber measurements and inventory cruising through the Ministry of Forests Resource Inventory Branch and VRI programs. MOF certified cruisers will carry out the NVAF sampling.

Vancouver Ministry of Forest (MOF) regional staff, in cooperation with the senior supervisor at Olympic Resource Management (ORM), will be responsible for field sampling quality assurance audits. A minimum of 10% of the samples will be checked with auditing occurring throughout the duration of the project.

Compilation

The MOF ground sample data entry system and compiler will be used. The Ministry has offered to do the compilation using this approach. Field sheets will be checked and submitted to the Ministry for this purpose.

Adjustment of Phase I Estimates

The ground samples will be post stratified into species groups by leading species (and silvicultural treatment such as spacing and fertilization where the number of samples is sufficient). Where the number of plots is too small (probably < 6) in a stratum, strata will be combined in a logical manner keeping samples with similar ecological characteristics together.

Weighted totals for variables to be adjusted will be calculated for samples in each stratum. A similar computation will be carried out for Phase I estimates of each variable in the sampled polygons and a ratio formed between $Var_{phase\ II}/Var_{phase\ I} = R$ (adjustment ratio).

Schedule

The VRI will be implemented in 2001 as follows:

1. Select sample polygons (January).
2. Select sample locations in polygons (January).
3. Prepare sample packages (January).
4. Select a random set of sub-samples for NVAF sampling (January).
5. Submit Sampling Plan for review by MOF Vancouver Region (February).
6. Locate and measure the sample clusters (January - February, ORM).
7. Conduct 10% quality assurance (February, MOF Vancouver Region).
8. Sample NVAF sample clusters by Expert Cruiser (February, ORM).
9. Complete stem analysis (February – March, ORM).
10. Validate and compile data from completed sample clusters and prepare inventory summary reports (March).
11. Conduct statistical analysis and adjust inventory files (March).

Roles and Responsibilities

Western Forest Products

- Select sample polygons and sample point locations.
- Coordinate project activities, and ensure all contractors are qualified and certified, tender and manage fieldwork contracts.
- Advise contractors on access routes and potential tie points.
- Check data after initial compilation.
- Complete database analysis.

Olympic Resource Management

- Prepare sample packages.
- Assess access and coordinate the use of helicopters.
- Complete field sampling.
- Conduct internal quality control.
- Enter sample data.
- Complete NVAF call grading/net factoring and destructive sampling.
- Validate and compile data.

Ministry of Forests, Vancouver Region

- Pre-numbered aluminum identity tags.
- Digital grid used for random sample location.
- Compilation of field samples from digital submission.
- Field tally cards.
- Complete quality assurance of VRI and NVAF samples, and issue quality certificates.
- Review sample and population comparison.
- Prepare quality assurance report.

Approximate Costs

Sample sizes and contract awarded rates for VRI and NVAF enhancements for TFL 6 are listed in Table 3.

Table 3. Cost schedule for VRI and NVAF sampling for TFL 6.

VRI/NVAF Activity	Sample size (clusters)	Unit Cost($)	Total Cost ($)
Administration/Project Management			4,3000.00
Data Preparation			5,500.00
VRI Field Sampling	100	2,530.00	253,000.00
NVAF destructive sampling	60 trees	633.33	38,000.00
Quality Assurance			17,300.00
Data entry (VRI and NVAF)			7,700.00
GPS, Age Microscope Counts			5,500.00
Ratio Adjustment Analysis			5,000.00
Total			375,000.00

Appendix A – Sample Selection

The steps used to select ground samples to be used in the TFL 6 VRI project are outlined below.

1. The database associated with the Phase I classification was checked for any anomalies.
2. A GIS overlay combining the VRI Phase I classification and ecosystem classification was completed so that immature polygons could be clustered into productivity groups.
3. A volume for individual mature polygons was calculated using VDYP to allow polygons to be clustered into volume groups.
4. The classification was partitioned based on the Landcover classification to include only Vegetated Treed polygons.
5. From the resulting list, polygons were stratified base on species groups. These groups combined all polygons into either a Hemlock stratum or a Cedar stratum. It was from this stratification that the sample distribution was defined.
6. The population was then broken into further stratums to reflect productivity in young stands and volume classes in older stands. The table below reflects the breakdown:

Table 4. Stratum Breakdown for Sample Selection

Species Group	Age Group	Productivity/Volume Group	Area (ha)	% of population	# of Samples
Hemlock (Hw, Ss, Ba, Hm, Fd)	Young	Good	3449.6	4%	***2***
		Medium	66556.6	87%	***40***
		Poor	6796.8	9%	***4***
	Young Total		76802.9	***64%***	46
	Old	High	6968.9	16%	***4***
		Moderate	31226.7	73%	***18***
		Low	4534.5	11%	***3***
	Old Total		42730.1	***36%***	25
Hemlock Total			119533.1	100%	**71**
Cedar (Cw, Yc, Dr, Pl, Ac)	Young	Good	1693.1	12%	***1***
		Medium	5924.3	43%	***3***
		Poor	6164.2	45%	***4***
	Young Total		13781.6	***28%***	8
	Old	High	1385.4	4%	***1***
		Moderate	14510.3	42%	***9***
		Low	18946.1	54%	***11***
	Old Total		34841.8	***72%***	21
Cedar Total			48623.4	100%	**29**
Total			168156.5		**100**

7. Once each strata was defined the individual polygon areas beginning with the first polygon in the stratum to the last polygon in each stratum was accumulated.

8. As many random numbers as there were allocated samples for each stratum was generated. The random number ranged in size between 0 and the total area of each stratum.
9. The generated random numbers were used to identify the sample polygons. A polygon was selected if a generated random number was larger than the accumulated total area corresponding to the polygon immediately preceding it, and the random number was smaller than or equal to its accumulated area. A polygon had the potential to be selected more than once; however, this did not happen in this project.

Once the polygon selection for each stratum was completed the next step was the determination of a plot location within each polygon. This was done using the provincial-wide sampling 100 x 100m grid that coincides with the federal National Forest Inventory grid.

The steps in selecting the sample location within the polygon:

1. The 100 m grid was overlain on the Phase I polygons and a list made of all grid points falling within each polygon. Each grid point was given a unique ID.
2. A random point was selected within each sample polygon. This random selection was completed by counting up the total number of point within the polygon and than generating a random number between 0 and the total number of points found in the polygon.

The steps taken in selecting the ground samples that would be enhanced for NVAF are outlined:

1. Ground samples were stratified into two age groups: immature and mature by using 120 years as the boundary between age groups.
2. It was then determined that 12 ground samples from the mature group would be selected for NVAF enhancement and 8 ground samples from the immature. **As a general rule, the number of ground samples needed equals the total number of sample trees divided by 3.** For example, if 60 live trees are required, then 20 ground samples should be selected.
3. Each age group strata was sorted by leading species.
4. Ground samples were selected systematically from each age group by calculating the selection interval by dividing the target number of ground samples by the number of samples in the age group. Generating a random number and multiplying this number by the selection interval determined a random start. The next ground sample in the sorted list was then selected for NVAF. The selection interval was then added to the random start and the next ground sample in the sort position was selected. The remaining ground samples were selected by continued adding of the selection interval to the selection number and so until the end of the sorted list of samples was reached.

Appendix B – List of Sample Polygons

Sample #	Polygon	Leading Species	Area (ha)	UTM X	UTM Y	NVAF
1	19114	Hw	3.46	584482.9	5604172.7	
2	7882	Hw	7.74	589384.2	5589777.0	
3	6512	Hw	18.77	589126.5	5586366.4	
4	6624	Hw	16.64	599412.1	5586694.9	NVAF 14
5	62	Hw	23.39	620302.6	5567564.2	
6	5650	Hw	14.54	595514.9	5584232.9	
7	15329	Hw	84.06	609496.4	5601514.6	
8	20255	Ss	5.71	561021.2	5605589.3	
9	4628	Hw	9.61	590307.9	5582016.1	
10	10111	Hw	13.75	604761.8	5595117.4	
11	11724	Hw	6.79	618884.5	5597003.5	
12	13974	Hw	85.64	607341.4	5600425.0	NVAF 15
13	18193	Hw	45.36	622896.5	5603970.6	
14	28553	Hw	17.66	578190.7	5615911.3	
15	2428	Hw	49.21	617618.9	5576851.5	
16	15718	Hw	96.21	617974.6	5602066.4	
17	6883	Hw	36.46	613071.4	5587662.3	
18	8092	Hw	37.71	582646.1	5590695.5	NVAF 16
19	28774	Hw	18.24	578652.3	5616830.9	
20	11267	Hw	7.7	588302.3	5596531.8	
21	22926	Hw	9.07	570816.8	5608100.9	
22	5336	Hw	33.32	606528.2	5583890.9	
23	19869	Hw	26.3	586051.0	5604938.3	
24	21366	Hw	12.36	580767.6	5606917.7	
25	20994	Hw	64.51	579461.4	5607063.0	NVAF 17
26	20329	Hw	19.04	581999.1	5606169.1	
27	28963	Hw	22.61	567931.0	5617281.4	
28	7027	Hw	6.87	596858.4	5587988.6	
29	1946	Hw	41.09	606788.9	5575202.8	
30	27761	Hw	5.68	579580.7	5613769.1	
31	28867	Hw	8.4	571038.8	5617111.8	
32	6845	Hw	16.33	587978.5	5587518.4	NVAF 18
33	7930	Hw	17.68	605755.4	5590458.6	
34	15961	Hw	77.82	628662.1	5602408.8	
35	28353	Hw	57.49	573618.7	5615219.6	
36	28304	Hw	13.85	572017.0	5615252.5	
37	28182	Hw	28.22	573032.2	5614895.0	
38	8996	Hw	6.21	608263.9	5592662.8	NVAF 19
39	14077	Hw	12.77	630263.0	5599974.6	
40	12571	Hw	17.48	610623.3	5598461.1	
41	12555	Hw	30.17	618027.9	5598368.2	
42	28367	Hw	20.05	570111.6	5615372.6	
43	29439	Hw	10.27	564668.9	5618744.7	

Sample #	Polygon	Leading Species	Area (ha)	UTM X	UTM Y	NVAF
44	21881	Fd	4.91	627665.2	5607168.5	
45	6797	Hw	6.25	585795.0	5587127.3	
46	21177	Hw	12.86	626783.0	5606731.9	NVAF 20
47	8532	Hw	17.13	599599.6	5591802.6	
48	7491	Hw	129.88	602610.8	5589127.9	
49	8627	Hw	12.9	601400.6	5591777.5	NVAF 10
50	7409	Hw	51.04	597806.8	5589228.0	
51	28207	Hw	12.85	565731.1	5614888.5	
52	12994	Hw	3.92	565715.7	5598586.2	
53	11618	Hw	33.77	585365.6	5597409.1	NVAF 9
54	6840	Hw	33.75	600884.6	5587356.2	
55	6724	Hw	22.19	609897.7	5587030.6	
56	6544	Hw	7.65	600323.0	5586432.9	
57	4427	Hw	5.24	593822.2	55816623.6	NVAF 8
58	2702	Hw	6.74	609093.3	5577498.1	
59	2052	Hw	48.27	618346.6	5576181.7	
60	9185	Hw	20.39	563134.5	5593377.8	
61	1683	Hw	13.5	603424.4	5574363.3	NVAF 7
62	29753	Hw	9.45	571158.2	5621417.9	
63	26160	Hw	6.04	583079.9	5611415.1	
64	23738	Hw	6.43	598797.2	5608670.6	
65	18860	Hw	2.68	563193.2	5603880.5	NVAF 6
66	17245	Hw	24.78	591529.8	5603066.9	
67	15412	Hw	96.69	573198.0	5601400.2	
68	15266	Ba	6.62	584221.2	5600861.5	
69	3376	Hm	4.81	618709.4	5579496.3	
70	14780	Hw	7.54	568219.1	5600891.3	
71	3994	Hw	12.82	593651.6	5580955.6	NVAF 5
72	2217	Dr	16.22	611638.3	5576403.8	
73	23937	Cw	31.22	589374.4	5609177.7	NVAF 13
74	19995	Dr	8.04	581337.8	5605241.3	
75	21011	Cw	28.85	613873.6	5606897.2	
76	11636	Dr	1.88	595086.6	5596914.7	
77	17762	Cw	70.53	629519.5	5603444.4	
78	9584	Cw	17.17	606192.6	5594376.8	
79	25627	Pl	31.71	557092.1	5611024.7	
80	285	Cw	9.84	619825.0	5569444.0	NVAF 1
81	21132	Cw	22.18	623991.4	5606516.4	NVAF 4
82	8606	Cw	22.08	567281.6	5592252.0	
83	14992	Cw	7.97	563019.6	5600873.0	
84	11692	Cw	16.85	560587.8	5596870.7	
85	9186	Cw	6.4	566445.3	5593116.8	NVAF 3
86	28037	Cw	2.64	568556.0	5614307.1	
87	860	Cw	14.98	616706.9	5572314.4	
88	20795	Cw	1.89	564997.8	5606156.5	
89	18022	Cw	1.98	561022.1	5603189.2	NVAF 2

Sample #	Polygon	Leading Species	Area (ha)	UTM X	UTM Y	NVAF
90	27476	Cw	26.75	612801.2	5613454.1	
91	10929	Yc	31.99	624916.1	5596253.1	NVAF 12
92	26521	Yc	222.45	587206.5	5613187.9	
93	6534	Cw	4.65	603230.3	5586253.8	
94	5305	Yc	12.33	601029.9	5583862.4	
95	28654	Cw	9.73	579268.1	5616456.6	
96	27642	Yc	78.8	588467.0	5614140.8	
97	25796	Cw	1329.39	592889.6	5611224.8	
98	25430	Yc	10.41	594524.6	5610392.9	NVAF 11
99	19110	Cw	10.36	563575.8	5604296.6	
100	380	Yc	7.93	612597.6	5570144.7	

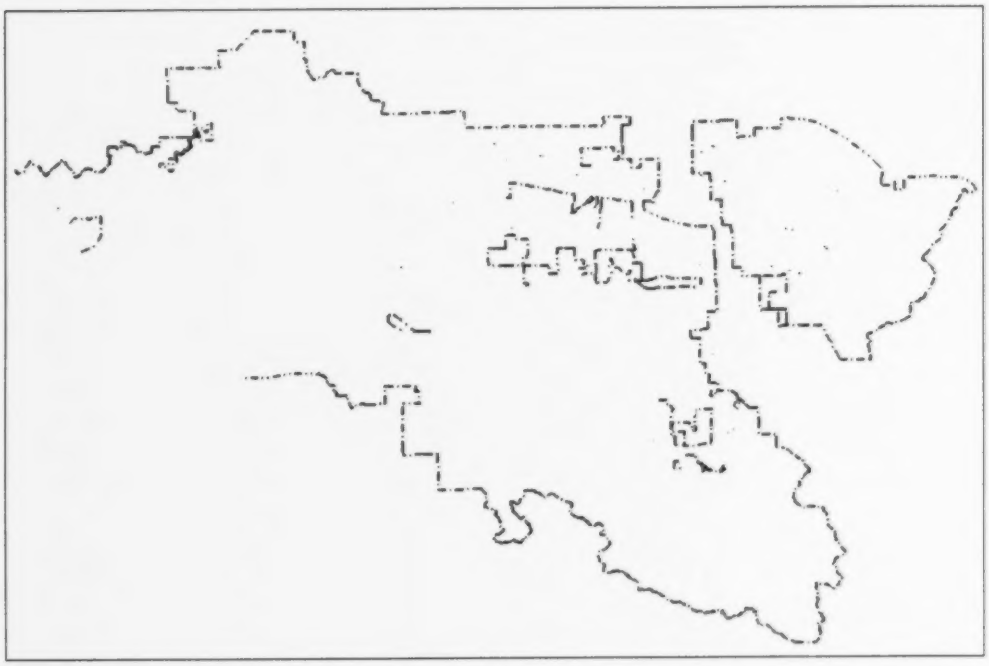

Figure 3. TFL 6 Ground Sample Distribution

Appendix C – Comparison between the population and the sample polygons

The following graphs and table depict the comparison between population and sample percentage by Site Index, Age Class and Leading Species. The population values are area percentages, and the sample values are proportions of number of samples. The graphs and table suggests that the selected sample is representative of the Vegetated Treed target population.

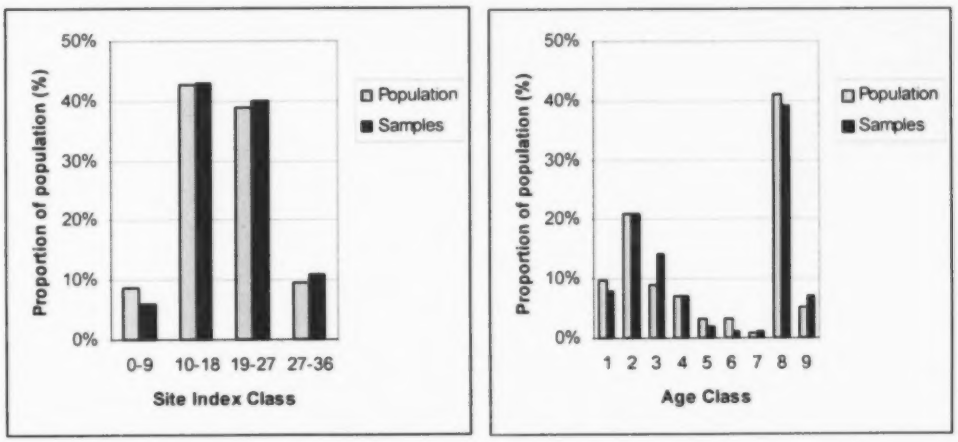

Figure 4. Distribution of target and sample population by site index and age class.

Table 5. Comparison of Population Area vs. Samples

Species Group	Age Group	Productivity	Population	Samples
Hemlock	Young	Good	4%	4%
		Medium	87%	87%
		Poor	9%	9%
	Young Total		64%	65%
	Old	High	16%	16%
		Low	11%	12%
		Moderate	73%	72%
	Old Total		36%	35%
Hemlock Total			**71%**	**71%**
Cedar	Young	Good	12%	13%
		Medium	43%	38%
		Poor	45%	50%
	Young Total		28%	28%
	Old	High	4%	5%
		Low	54%	52%
		Moderate	42%	43%
	Old Total		72%	72%
Cedar Total			**29%**	**29%**